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Human Biogeography in the Solomon Islands

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As Ernst Mayr (1969) has observed, the "richness of tropical faunas and floras is proverbial." Although the degree of species diversity in the tropics has at times been exaggerated, tropical bird faunas, for example, "contain at least three times if not four or more times as many species, as comparable temperate zone bird faunas." It is not surprising then that a tropical island as large as New Guinea in the southwestern Pacific has played a special role in the refinement of evolutionary theory (Diamond, 1971, 1973).

In similar fashion, anthropologists have long recognized that the Melanesian islands of the Pacific, including New Guinea, are remarkable for the extreme degree of ethnic diversity encountered on them (fig. 1). While the magnitude of the dissimilarities among these tropical human populations has been occasionally overstated or misconstrued (Vayda, 1966), even casual survey of the findings made by social anthropologists, archaeologists, physical anthropologists, and linguists in Melanesia would confirm Oliver's (1962, p. 63) assessment that no other region of the world "contains such cultural variety as these islands."

It is not an accident that zoologists, botanists, and anthropologists have observed that one word, *diversity*, so aptly sums up the character of tropical populations in general, and the island populations of Melanesia in particular. This common judgment, however, has not led to the development of a shared set of concepts and models, applicable at least in part both to lower organisms and to man, to account for that diversity. Although New Guinea has been for years "a mecca, albeit difficult of access and penetration, for students of evolution" (Diamond, 1971, p. 69), anthropologists have

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customarily shied away from evolutionary interpretations purporting to explain ethnological variety. Melanesia's human diversity has been seen primarily as testimony for diffusionist and migrationist reconstructions of mankind's ancient and more recent prehistory, and as a rich mine of evidence attesting to the extensive variation possible in the realm of culture. The reluctance of many anthropologists to pursue the evolutionist's approach to diversity reflects philosophical beliefs about human nature, the indeterminism of historical events, and the uniquely varying totality of each of mankind's many differing cultures. These beliefs have been popular within anthropology for decades (Sahlins and Service, 1960).

In recent years, anthropologists working in many areas of interest and in many parts of the world have begun to reconsider if their profession has been wise to reject social evolutionism as a form of naive "reductionism" or as a false "biological analogy." Since the last world war, many other sciences have experienced what the geographer, Ian Burton, has called the "quantitative revolution": that is, they have come to insist more than before on quantitative, statistical methods of research, and "an attendant emphasis on the construction and testing of theoretical models" (Burton, 1968, p. 13).

Quantification and model-building may not inevitably lead to evolutionism. Yet, as Leslie White (1960, p. vii), one of the earliest and most vocal champions for a return to evolutionism in cultural anthropology, has written: "The concept of evolution has proved itself to be too fundamental and fruitful to be ignored indefinitely by anything calling itself a science."

Intellectual trends within the science of geography have always closely paralleled those in anthropology (Mikesell, 1967). Thus, what another geographer, Peter Ambrose, has related about the significance of the quantitative revolution of late years in that science should have relevance to anthropology. Perhaps the chief issue at stake during the revolution has been the question whether the behavior and development of human societies were predictable. According to Ambrose (1969, p. 13):

The central problem is perhaps not "Is man's collective action ever predictable?" since daily life would be impossible if it were not based on all sorts of instinctive predictions about how other people and institutions will behave. The operational question is "Are we ever likely to know enough about the way people behave and interact in groups, and in the environment, to enable us to

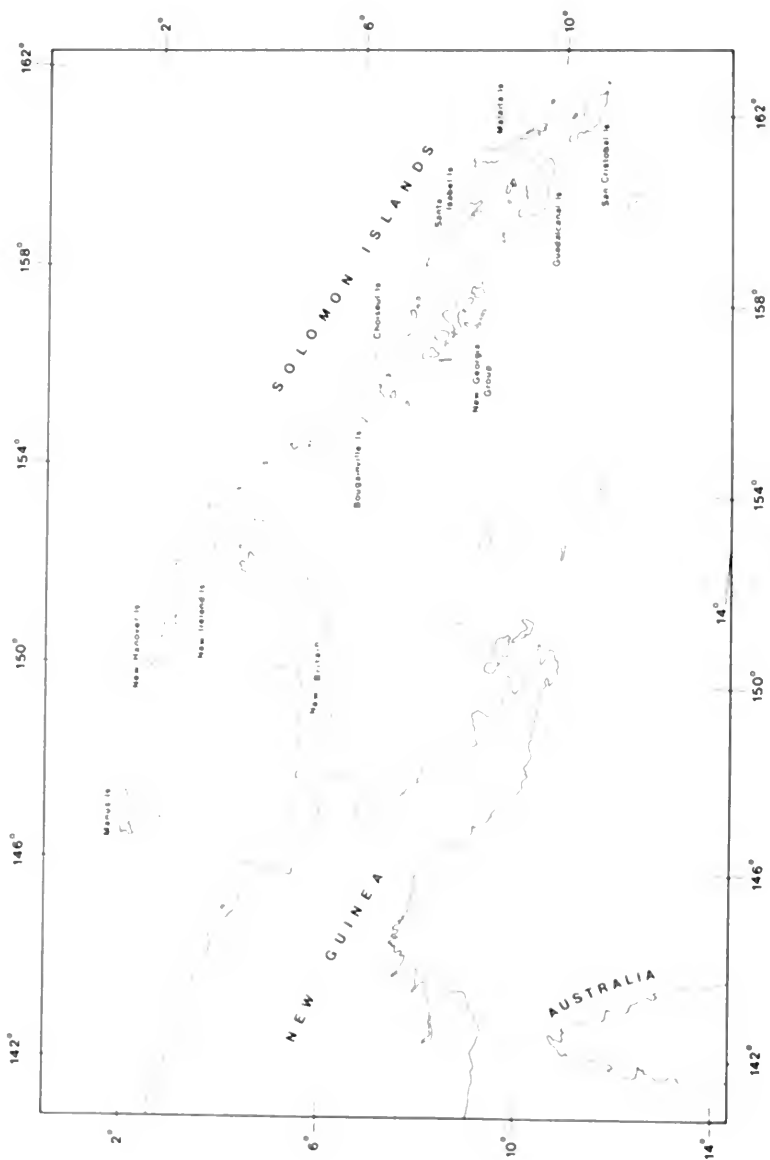


FIG. 1. The islands of western Melanesia.

carry out valid predictive work rather than purely descriptive work?" Many social scientists, including human geographers, are showing implicitly in their research, and explicitly in their methodological statements, that they believe the answer to the second question to be "Yes." It should be borne in mind that prediction in this sense does not depend upon the accurate forecasting of the actions of every individual over a given future period. What is involved is the statement, within specified levels of probability, that a human group will tend to behave in a certain way given a stated choice of possible alternatives.

The quantitative revolution has influenced the conduct of research and discovery in many of the social sciences, especially geography, economics, sociology, and psychology. Its impact has been felt also in other sciences concerned with the description and analysis of population behavior. In the past 10 to 15 years, for example, quantitative and paradigmatic advances have transformed population biology, biogeography, and ecology.

In view of this trend toward quantification and predictive model-building, there is justification for arguing that students of anthropology, particularly those of human evolution and archaeology, should reconsider the problem of man's great diversity in Melanesia from perspectives that are detached from the idiographic, historiographic tradition of previous research in the area and which are inspired instead by the theoretical and procedural achievements exemplified by current work in geography, population biology, mathematical biogeography, and ecology.

This report describes a research program initiated in 1973 at Field Museum of Natural History under my direction entitled: "Comparative Human and Lower Animal Biogeography in the Solomon Islands." This account records how "human biogeography" is being defined during this project, surveys the kinds of data examined, notes some of the research problems that are being raised, and reviews two initial studies that were undertaken to ascertain how effectively certain principles and models previously worked out in the field of lower animal biogeography can be utilized as well to study the human populations of the Solomons.

Definitions

In 1957 Pierre Dansereau (1957, pp. 3, 319), a botanist, defined *biogeography* as "the study of the origin, distribution, adaptation, and association of plants and animals." He (1957, p. 323) described *ecology* as "the study of the reactions of plants and animals to their immediate environment, to their habitat (and not to their geographical location)." While it may be unwise to separate ecological

endeavors today sharply from biogeographical ones (MacArthur, 1972), it can be seen that contemporary ecology and biogeography do not present themselves as simply two alternative academic disciplines with the same range of perspectives on the world. At very least there is a difference in *scope* between the aims of the biogeographer and those of the ecologist, a difference which appears in practice, if not always in theory.

In their pioneering treatise on theoretical island biogeography, MacArthur and Wilson (1967, p. 185) describe biogeography as the study of "the distribution of species of organisms over the face of the earth. Biogeography is concerned with the limits and geometric structure of individual species populations and with the differences in biotas at various points on the earth's surface. The local, ecological distribution of species, together with such synecological features as the structure of the food web, are treated under biogeography only insofar as they relate to the broader aspects of distribution."

The earlier definition of biogeography given by Dansereau and this one by MacArthur and Wilson comprise a foundation upon which to develop a definition of the phrase "human biogeography" used throughout this paper. Since MacArthur and Wilson, as well as Dansereau, distinguish between ecological concerns and biogeographical ones, it is best to begin with a definition of "human ecology," and then to observe that a similar contrast can be drawn between that area of interest and human biogeography.

Human ecology is the study of relationships between human populations and their immediate environment, including other species populations (see Bates, 1953). As the geographer Barrows (1923, p. 3) argued years ago, human ecology investigates "relationships existing between natural environments and the distribution and activities of man."

In contrast, *human biogeography*, as thought of here, is the study of the size, distribution, and population structure of, and the interactions among, human populations found in similar or divergent habitats, and of the conditions and events leading to the development and maintenance of similarities and differences among human populations living at various points on the earth's surface.

These two definitions imply a difference in both scope and subject matter. While biogeographical research often includes the investigation and understanding of ecological relationships at the local level, it also incorporates analysis of the origin, development, and

maintenance of formal and functional similarities and differences among and within populations. The data of human biogeography thus include information on the history, characteristics, distribution, and relationships, in addition to the ecology, of human groups at the regional and global scale.

To describe human biogeography, use has been made of several concepts and terms:

population size: biologically, the number of potentially interbreeding individuals at a given locality (the "local population" of Mayr, 1970, p. 82). May be more generally defined as the number of individuals within an area which interact in a designated fashion at a potential frequency determined to be in accord with the purpose of the study at hand.

population distribution: the geographical occurrence of a population in space and time.

population structure: the manner in which the components (i.e., individuals, neighborhoods [Rohlf and Schnell, 1971], sub-populations) of a population are inter-related in space and time; the pattern of distribution of such components (linear, random, clustered, etc.). In other words, the arrangement of their occurrence within a determined area and during a given unit of time.

population interaction: the exchange of individuals, energy, genetic material or information among the components of a population or among populations; the effect of one component or population on another; the movement of one component or population relative to others leading to a change in effective relationships.

These concepts, as defined, are intimately related to each other. The chief underlying ideas are those of number, frequency of occurrence in space and time (i.e., relative abundance), location, and mutual effect. Therefore, the definition of human biogeography, and of the components said to be its units of study (individuals and groups or populations of individuals), is implicitly a systems approach (von Bertalanffy, 1968) to the spatial-temporal organization of human societies and to the evolution of man's biological and cultural diversity. Considering the vogue popularity of "general system theory" today, however, there is no need to emphasize this feature of the approach being advocated.

There is a need to indicate how human biogeographical research differs from customary studies long undertaken in anthropology or geography. Further, it is necessary to demonstrate that such investigations are practical and effective.

First, the kinds of subjects and relationships subsumed under the rubric "human biogeography" are by no means foreign to anthropologists and geographers. What distinguishes human biogeography from other related pursuits is twofold: (1) biological populations, rather than geographical "regions" or anthropological "cultures" and "societies," are taken as the effective unit of interpretation; (2) investigation is focused on the search for regularities, or patterns, in the characteristics, organization, and behavior of human populations living under similar or divergent geographic circumstances and in different parts of the world. Thus, unlike geography or anthropology, the study of human biogeography is specialized and comparatively narrow. At the same time, its goals are more akin to work in zoology, biology, and ecology than much of past and current research in anthropology and geography.

Second, the utility of work in human biogeography can be demonstrated by examining the kinds of information about human and lower animal populations in the Solomon Islands available for biogeographical analyses.

A review of some of the existing biogeographical work on lower animals in the Solomons will point out the kinds of research questions of interest to biogeographers and some of the patterns and processes already observed that might have relevance to the study of human populations in the archipelago. Following this review, various perspectives on mankind's diversity in the Solomons will then be explored, and when appropriate, tentative biogeographical comments will be offered, before turning to two specific research topics.

Lower Animal Biogeography

Appropriately, the scientist who pioneered the study of natural history in the Solomon Islands, Henry Guppy, was also the man who gave us one of the earliest and most comprehensive surveys of the anthropology of the archipelago (Guppy, 1887). Since Guppy's day substantive research in both natural history and anthropology has been combined only rarely, although anthropologists have kept up at least peripheral interest in flora and fauna of economic importance to the islanders, and zoologists have contributed articles, in a

more or less popular style, on native life and customs (Mayr, 1930-1931; 1943; Mann, 1948). Few scholars working in these fields of endeavor have weighed seriously the possibility that a combined study of the biogeography of man and lower animals in the Solomons might be instrumental in enhancing our understanding of population dynamics and prehistory on these islands or among similar socio-economic populations elsewhere in the world.

The most influential research on lower animal species in the Solomon Islands has been that by Ernst Mayr on bird faunas (for a summary, see Mayr, 1969). Synoptic studies by P. J. M. Greenslade (1968a, b, 1969) on island patterns in bird and insect diversity, however, may be used to illustrate the general relevance of lower animal research to the anthropology and archaeology of the islanders. Greenslade's syntheses are particularly germane, because he has framed his reports in the innovative theoretical tradition associated with the late Robert MacArthur and Edward Wilson, alluded to previously.

According to Greenslade, the striking feature of animal distributions in the Solomons and elsewhere in the Pacific is the occurrence of endemic species and subspecies which are to be found on only one or a few islands. Although, as a result, patterns of faunal similarities and differences among islands are complex, he (1969, p. 274) demonstrates that the biogeographical problems presented by restricted island distributions within the Solomons "can be analysed simply in terms of the existing islands, their areas and distances from each other and from major sources."

His own efforts to define the principal faunal patterns in the Solomons and explain their probable origin rely upon several basic assumptions which indicate some of the fundamentals of a biogeographical approach to species diversity:

1. Species, when expanding their geographic distribution, move most often from large islands to smaller ones, rather than the reverse. He justifies this assumption by noting that it may be derived readily from biogeographical theory, including the work of MacArthur and Wilson on island species equilibrium dynamics (see below: "Proximal-point analysis").
2. Historically, there has been a dominant west-to-east expansion of species out into the Pacific Basin from source areas in New Guinea and Mainland Asia. This claim is consistent with known

evidence on species distribution patterns in the Pacific (Zimmerman, 1942).

3. Narrow water gaps between islands are crossed more easily than wide divides. This assumption makes common sense, and is in accord with MacArthur-Wilson theory on island biogeography.

4. Species distribution patterns may be analyzed in terms of the existing geographical configuration of islands in the archipelago which probably dates from some time in the Pleistocene. Comparative evidence from elsewhere in the Pacific suggests that such a time-depth is sufficient for the degree of species differentiation observed in the Solomons to have developed. This last assumption is also in line with current theory which emphasizes the importance of species colonization and extinction as continuing processes in maintaining insular faunas.

Taking these assumptions, Greenslade proposes that the most important routes of species expansion from the west down the Solomons chain can be diagrammed as in Figure 2. He notes that the



FIG. 2. Main routes and directions of faunal movement in the Solomon Islands (after Greenslade, 1969, fig. 16).

main route from Bougainville to Nggela, although sketched by assessing relative island areas and widths of water barriers, corresponds with a possible land bridge during the low sea-levels of the Pleistocene. He judges this former land connection, however, to be less important to present-day faunal distributions than the narrowness of the existing water gaps.

Greenslade constructs this pathway diagram to forecast the most probable species patterns in the Solomons, in order to determine how successfully observed distributions coincide with expectations derived independently from his initial assumptions. There is no reason, however, why rough modeling of this kind in biogeography must be limited to the prediction of historical migration trends. In fact, it need not be, as a later discussion of a procedure in human biogeography, termed "proximal-point analysis," will demonstrate.

Greenslade goes on to show that for both birds and insects two major distribution patterns dominate in the Solomon Islands. First, in both cases there is a high incidence of island endemics on San Cristobal, located at the most easterly extreme of the archipelago. Second, the islands from Bougainville to Nggela postulated to be on the main route for species expansion do, indeed, constitute a distinct group of islands with inter-related faunas. Since the exceptional degree of endemism on San Cristobal is also to be expected from Greenslade's pathway diagram, both major patterns suggest that his approach has much to recommend it.

The recognition of these and other lesser distributional patterns in the Solomons is in itself a significant contribution to lower animal biogeography, because it affirms that variables such as island area, the distance between islands, and the degree of an island's isolation and distance from potential source areas are as important in determining patterns of species diversity as generally assumed in theoretical island biogeography. If this is the case, then there is reason to argue that efforts should be made to determine how effectively such variables may be used to analyze human biological and cultural diversity in the Solomons. As Greenslade (1969, p. 274) has clearly stated: "Only if these factors fail to account for observed animal distributions is it necessary to introduce any others."

The relevance of Greenslade's work to human biogeography, however, does not end merely with this broad claim. Greenslade further develops the argument that the two main distribution patterns represented by San Cristobal and the Bougainville-Nggela fauna chain can be explained best by hypothesizing a series of three successive stages in the expansion of taxa eastward through the Solomons, stages in what he envisions as a continuing "taxon cycle" of species expansion, subsequent local differentiation, and final distributional contraction (cf. Wilson, 1961).

Greenslade's development of his concept of a Solomon Islands taxon cycle as a logical process of expansion from source areas farther west creates a distinct possibility that what he has to say might be adopted in human biogeography as a first-order approximation in efforts to define processes behind human immigration, cultural diffusion, and local island diversification in the archipelago. Although, as he himself notes, actual species distributions are often more complicated and less clear-cut than suggested by his taxon

cycle,' the model is especially provocative because he has been able to correlate the stages he outlines with important ecological and adaptive changes.

According to Greenslade (1969), individual species may be classified by their pattern of distribution in the Solomons into one of these three stages:

Stage I: Initial expansion through the Solomons

Species at this stage in their history are in the process of expanding their range of geographical distribution from the local source area to the east, Bougainville Island. Also included in this stage are species that have continuous distribution throughout the archipelago, without evidence for the onset of local differentiation.

With respect to habitat preferences, species at this point in their local history live either in a wide range of habitats, or occur at low elevations, especially in temporary coastal environments where it is probable that species are selected for their migratory ability, which would preadapt them for inter-island dispersal. Faunas in such habitats are also commonly of low diversity, and immigrant species arriving in these areas are likely to face only limited competition.

Stage II: Differentiation

Species classified in this stage give evidence of having differentiated into local taxa, with perhaps some suggestion of extinction on small or isolated islands, and possibly secondary expansion as well from large to small islands.

Stage II species in the Solomons are to be found almost exclusively in the lowland rain forest. At least on larger islands in the archipelago, the Stage II shift in habitat preference marks an increase in species diversity and a probable higher incidence of competition. In observed cases, there is a strong suggestion that Stage II species have adapted themselves to specific local conditions, "especially if the habitat shift is associated with any loss of dispersal ability and consequent break up of the population on an island into smaller units" (1969, p. 278).

Stage III: Distributional contraction

Species at this stage show fragmented and discontinuous distributions, and appear to be contracting their total area of occurrence.

¹According to Diamond (pers. comm.), Greenslade's taxon cycle is incomplete and many species patterns cannot be fitted to it.

Many Stage III species have withdrawn to mountains or, in some instances, small or isolated islands, where there is a possibility that competition is lower than in the rain forest.

The pertinence of this logical model to the study of human groups is observed in the questions relating to human biogeography that the model raises. For instance, Greenslade emphasizes by means of the taxon cycle that colonization and local extinction are continuous processes which serve to maintain island faunas. How legitimate is the assumption that similarly continuous processes affect human populations in Melanesia? Further, Greenslade also proposes that the stages in the taxon cycle operate along predictable routes through the Solomons. Can the paths of human migration and inter-island affinities also be predicted in a fashion comparable to that taken by Greenslade?

In developing the idea of a Solomons taxon cycle, Greenslade points out the importance of factors such as dispersal ability, habitat range, competition, and extinction in determining species distributions. Are immigrant human populations "pre-adapted" for dispersal? Are they likely to show a wide habitat range? Is it probable that migrants will settle in temporary coastal environments, where they might face less "competition" from previously-arrived human groups? Is it possible that human populations tend to develop through stages comparable to the three outlined for lower animal species? If human populations shift from coastal areas to the lowland rain forest, do they also tend to fragment into smaller settlement units? Is there something comparable in human biogeography to the heightened inter-species competition in the rain forest? How does geographic location and habitat preference affect the likelihood of extinction among human populations?

These are only a few of the questions that could be raised through comparative study of human and lower animal biogeography in the Solomon Islands. Certainly questions such as these are not without precedence in anthropology and archaeology. Nonetheless, it may be argued that an explicitly comparative approach brings the ecological, geographical, historical, and biological issues involved sharply into focus. Moreover, comparative study points to possible solutions already explored in animal biogeography, solutions which can function at very least as a foundation upon which to develop models and explanatory hypotheses in human biogeography.

HUMAN BIOGEOGRAPHY

The human diversity of the Solomon Islands can be observed from a number of perspectives: in biology, language, geographical circumstance, social and material culture, and in prehistory. Although the existing level of information on these perspectives is insufficient for extensive work in human biogeography, there is reason to believe that the adoption of theoretical and procedural approaches such as those advocated here might redress the balance considerably. In the process, it seems probable that anthropological research in the Solomons can be integrated more closely with ecological and biological studies in the archipelago.

Human biological diversity

It has long been recognized that the islanders living in the Solomons differ among themselves in their physical appearance. The northern islands, from Nissan some 40 miles north of Buka on down to the New Georgia area, are commonly known as the "black spot" of the Pacific in which the skin color of the islanders approaches that of the darkest African populations (Oliver, 1949, p. 13). It has also long been claimed that the density of skin pigmentation steadily declines as one travels south of this region along the Solomons chain (Firth, 1944, p. 632). In addition, the small, isolated islands of Rennell, Bellona, Ontong Java, and Sikaiana are some of the famous enclaves of Polynesian-speakers in island Melanesia. These islanders appear physically unlike their Melanesian neighbors and resemble, instead, the island populations farther east with whom they appear to be tied linguistically (Simmons and Gajdusek, 1966; Willis and Booth, 1968; Booth and Vines, 1969).

Since World War II the pace of modern biological research on the genetics of the Solomon Island populations has increased rapidly. While today genetic research is far from comprehensive, a major program carried out since 1966 by teams from Harvard University working on Bougainville and Malaita has greatly expanded our knowledge of at least these islanders (Damon, 1973). Perhaps the most significant finding to date for human biogeography is the recognition of a possible cline in the distribution of the *Inv*¹ allotype of human immunoglobulin G, with a decrease in frequency from Bougainville to Malaita (Steinberg et al., 1972). Such a pattern suggests that the population structure of the chain of larger islands running along the eastern side of the archipelago may prove, in general, to have a clinal pattern (Mayr, 1970, pp. 215-217), a struc-

ture in conformity with the more crudely recognized pattern in skin color (above), and in accord with what might be expected on the basis of an elementary simulated network model of inter-island relationships (pp. 34-39). The pattern also agrees with what is known about the biogeography of variation in some species of lower animals, as noted previously.

Without further elaboration, continuing research on the biology and genetic structure of the Solomon Islanders should supply direct and useful information pertinent to human biogeography.

Linguistic diversity

In a recent study of the available linguistic information on the New Hebrides and the Solomons, George Grace (1971, p. 341) observes, as indeed others have before him, that both of these island territories "present the characteristic Melanesian picture of great linguistic diversity within a restricted area." Because knowledge of the languages of the Solomons is rudimentary, only a rough estimate can be given for the total number of mutually unintelligible tongues spoken there. The most extensive and complete listing (Capell, 1962) records the existence of nearly 80 Melanesian (i.e., Austronesian), Papuan (i.e., "Non-Austronesian"), and Polynesian languages in the British Solomons alone. If to this number the languages of the Papua-New Guinea Solomons are added (Allen and Hurd, n.d.), the total count runs up to over 100 separate tongues. Moreover, from the limited information available it is certain that if dialectal diversity were included, the figure might be several times this estimate.

Even though little is known about most Solomon Island languages, it is possible to arrive at a few general statements about them (Grace, 1971). First, Polynesian languages are found on a small number of the more remote islands. These so-called "Polynesian Outliers" are commonly interpreted today to be linguistic colonies derived from farther east: that is, foreign speech communities that have managed to survive perhaps because of their isolation from even their nearest Melanesian-speaking neighbors.

Second, although Papuan languages in the Solomons are similarly few in number, their occurrence so far from the New Guinea mainland, where most Pacific Island languages classified rather ambiguously as Non-Austronesian are to be found, is something of an enigma. It is a moot question, for instance, whether or not they represent ancient populations that were formerly more widely-

distributed and which have been replaced on most islands by later-arriving Austronesian-speakers (a pattern which would be comparable, in other words, to the distributions of those lower animal species in the Solomons that have reached Greenslade's Stage III in his postulated taxon expansion cycle). An alternative interpretation, however, might be that they are highly divergent but locally-evolved linguistic isolates that may be as little related to each other as they are to the dominating Austronesian language populations.

Linguists appear to favor the first solution to the problem presented by the Papuan languages. Yet they do not always agree on why Papuan-speaking communities have survived in the Solomons, precisely how and why they were replaced by Austronesian-speakers on the islands they may have once occupied (assuming there was in fact population replacement rather than language extinction), and why they occur not only in areas which could be described as "mountain refuges," but also on several of the smaller islands in the archipelago.

A major linguistic phylum of 12 Papuan languages and sub-languages exists only on Bougainville at the northern extreme of the Solomons (Allen and Hurd, n.d.). Elsewhere, languages also classified as Non-Austronesian appear on Vella Lavella, Rendova, New Georgia, Russell Islands, Savo Island, and in the Reef Islands — Santa Cruz group beyond the southeastern end of the chain (Wurm, 1971, pp. 631-632, 646-647).

The linguist Stephen Wurm (1973, pp. 2, 10-11) claims that these Papuan languages should be grouped with all the Non-Austronesian languages occurring in island Melanesia east of the main island of New Guinea. He believes that this "East Papuan Phylum" may be taken as evidence for inter-related prehistoric migrations by a "language group" originally in possession of the southeastern reaches of New Guinea Island.

Based on her own field research, Evelyn Todd (1973) of Trent University has proposed tentatively that at least the *Savosavo* (Savo Island), *Lavukaleve* (Russell Islands), *Baniata* (Rendova Island), and *Bilua* (Vella Lavella) Papuan languages can, in fact, be grouped together into a single family which she has termed the "Solomon Language Family." Building on a recent suggestion by Greenberg (Greenberg, 1971, pp. 816-819), Todd also proposes that the *Yele* language of Rossel Island in the Louisiade Archipelago near south-

eastern New Guinea Island should be included in the posited Solomon Family of Non-Austronesian languages.

Unlike Wurm, she has not explicitly drawn migrational inferences from this latter proposition. Indeed, again on evidence from her own original field work, Todd questions Wurm's claim that there is a demonstrable connection between at least one of the Non-Austronesian languages of Bougainville Island (the *Nasioi* language of the east coast), the *Baining* language of New Britain, and what she recognizes as the Solomon Family (including *Yele*).

Clearer knowledge of the development, maintenance, and affinities of the Non-Austronesian languages of the Solomons should provide useful information on human biogeography in the archipelago. While it may be possible to argue in some cases that the divergence of these languages from the rest of the languages in the Solomons has been maintained (and at least to a degree fostered) by their spatial or topographic isolation (e.g., the Bougainville Phylum), in other cases these linguistic populations occur in geographic locations where such an explanation would be difficult to entertain (e.g., *Savosavo*).

Third, apart from the relatively minor groups of Polynesian and Non-Austronesian languages, the majority of Solomon Island tongues are classified by linguists as "Melanesian Austronesian." Unfortunately, this allocation is less helpful than it might be, because the recognition of the class reflects as much the history of Oceanic linguistics as any sound linguistic reasoning (Grace, 1971, pp. 343-345). This observation underscores the point that the human biogeographer is just as dependent on the accuracy of fundamental taxonomic work as his botanical and zoological counterparts. There is little evidence to claim that the Melanesian languages of the Solomons, taken together, constitute a single genetic grouping within the vast assemblage of Pacific Austronesian languages (Grace, 1971, p. 347; Pawley, 1972, pp. 137-138).

Specifically, there are linguists who maintain that the languages spoken in the southeastern Solomons most closely resemble languages occurring in Polynesia, Fiji, Rotuma, and in certain areas of the New Hebrides. Moreover, they would exclude the languages of the western (British) Solomons (and probably also those of the northern Solomons, as noted later) from any grouping that incorporates the southeastern Solomons (Pawley, 1972, pp. 98-110). Briefly stated, the argument often put forward is: the languages of

the western and northern Solomons seem to be "idiosyncratic" or "less Austronesian" in character (Wurm, 1967, p. 33; Capell, 1969, pp. 147); those of the southeastern Solomons display a "more substantial Austronesian component" or are more "typically" Austronesian in form (Grace, 1971, pp. 345-349).

George Grace (1971, p. 349) has commented that the historical significance of this apparent difference between idiosyncratic and typical Austronesian languages has been variously interpreted and remains uncertain. According to some scholars, the contrast may reflect, in part, a difference in time of divergence (Grace, 1971, p. 346). Grace himself is one of a growing number of linguists who would interpret Polynesian, a case in point, as a "relatively recent offshoot" from certain ancestral languages commonly presumed to have been spoken somewhere in the southeastern Solomons (Pawley, 1972, p. 141).

In spite of the limitations and uncertainties of current linguistic evidence about the Solomon Islands, can such information contribute to human biogeography? A number of generalizations may be made which have biogeographical significance: (1) The total count of languages in the Solomon Islands is "impressively large" and "there is still no language with more than a few thousand speakers" (Grace, 1971, p. 350). Inevitable questions arising from these statements are: What conditions serve to maintain such small speech populations? Has so large a number of distinct, mutually unintelligible languages in so small a region evolved locally? How extensively must one posit "language group migrations" to explain observed affinities between separate tongues? How closely do distinct languages correlate with contrasting ecological environments? Alternatively, how far do the conditions of life regulating population interaction determine the maximum size that a given population may attain while continuing to preserve a more or less homogeneous language or set of mutually intelligible dialects?

(2) A small number of remote speech communities (i.e., the Polynesian Outliers) appear intrusive. Their occurrences give rise to the likelihood that these populations may be usefully examined to explore the kinds of events and circumstances that contribute to the colonization, survival, or extinction of divergent human populations within an island world.

(3) The linguistic diversity of the Solomons displays a degree of spatial patterning wherein the western (and, it is proposed here, the

northern) populations may be contrasted with those in the southeastern limits of the archipelago. How closely does this linguistic variation follow a clinal pattern?

(4) The divergence of the languages of the southeastern Solomons may reflect a difference in time of divergence. Specifically, those islands farthest from the Asiatic Mainland (presumably the "homeland" or original source area for the islanders) and nearest the scattered Polynesian-speaking islands of the central and eastern Pacific are also most like the Austronesian languages of Polynesia and the intervening New Hebrides. Can the linguistic evidence be employed to define probable patterns of advancing island colonization? Or is it necessary to propose a more complex and extensive pattern of human migrations out of New Guinea and perhaps Southeast Asia to account for observed affinities? With regard to this last possibility, some linguists would incorporate Austronesian languages found in the Bismarck Archipelago and on the Papuan Coast of southern New Guinea within the so-called "typical" class of Austronesian languages, while at the same time they have proposed excluding others occurring in the southern New Hebrides (Grace, 1971, p. 348; Pawley, 1972, p. 136).

In summary, close attention to linguistic diversity in the Solomons archipelago for evidence on migration (i.e. "colonization" in the biogeographical sense) and also on spatial-temporal differentiation (local linguistic evolution) should contribute much in future years to understanding the population structure, history, and networks of population interaction within and beyond the Solomons. A few examples supporting this observation will be given later in detail. At this point there is some reason to think linguistic diversity in this part of the world conforms relatively well to the kind of area/species diversity pattern often encountered on islands in the study of lower animal biogeography. Further, use of an elementary network model of the Solomons, alluded to previously, leads to the "prediction" that the linguistic populations living in the western and northern Solomons *ought* to be, as they indeed appear to be, observably different from those residing on the eastern and southeastern islands of the archipelago.

Geographical Diversity

To date the most comprehensive and ambitious attempt to determine how extensively man/land relationships in the Solomons have contributed to the evolution and maintenance of biological and cul-

tural diversity in the region would appear to be my (Terrell, 1976; summarized in Terrell, in press) own research on the peoples of Buka and Bougainville islands in the Papua New Guinea Solomons. The scheme of "geographic systems" devised for those islands is sufficiently analytical that it might be generalized as a model for work elsewhere. Currently, such an extension is planned under the aegis of the human biogeography research project at Field Museum.

Ethnological Diversity

Douglas Oliver (1962, p. 225) has written that "nothing short of an encyclopedia could fully describe the great variety of social forms and religious practices of all the Solomons." Indeed, "marked tribal differences . . . spell despair for anyone seeking a simple formula for understanding the Solomonese as an entity." It may not have been despair that led to the decline of comparative ethnology in the Solomons and elsewhere after its heyday at the turn of the century. Yet there is no doubt that few contemporary anthropologists have attempted to match the encyclopedic breadth of the pioneering ethnologists who wrote about island Melanesia (Guppy, 1887; Codrington, 1891; Rivers, 1914). For the most part, recent studies in Solomon Island comparative ethnology have been concerned only with selected aspects of material culture (e.g., Speiser, 1942a, b; Anell, 1955). Integrating formulas, simple or otherwise, have been remarkable for their rarity.

Nevertheless, there may prove to be a few useful formulas to distill from the seeming welter of ethnographic details, provided that the apparatus to do so is properly set up. For example, Blackwood (1931, p. 199) writes: "Buka and Bougainville are the two most northerly islands of the Solomon Group, but from the ethnological standpoint they differ from the better-known British Solomons in many important respects." Similarly, and more recently, Cranstone (1961, p. 47) at the British Museum observed: "Culturally and artistically the Solomon Islands can be divided into two main areas, each of which can be sub-divided: Bougainville, Buka and some smaller islands in the north-west, and the rest of the group."

Although impressionistic, statements such as these by Blackwood and Cranstone, taken in combination with more localized descriptions of specific islands or island groups (for example, Oliver, 1949, pp. 12-13), give the clear impression that the formula of spatial patterning could be applied successfully to the peoples and cultures of the archipelago. Indeed, when an explicitly popula-

tionist approach is used to analyze and comprehend ethnological diversity in the Solomons, the results are illuminating (Terrell and Irwin, 1972).

Without question, the best method to study the ethnological diversity of the Solomon Islands on an extensive scale is to observe directly what the islanders are doing "on the ground" (Leach, 1965, p. xiii). Until such field studies in human biogeography can be carried out, however, efforts at Field Museum will focus on renewed examination of items of Solomon Island material culture held among the extensive collections from Melanesia housed at the Museum.

Henry Cummings' pilot study of compound (*bonito*) fishhooks from the Solomons, published as the first issue of *Solomon Island Studies in Human Biogeography* (Cummings, 1973), succinctly demonstrates the feasibility and effectiveness of comparative work with museum collections. In spite of deficiencies in the provenance data available to him, Cummings has sketched a plausible geographic pattern that prevails over the diversity observable in hook types. On this evidence he has been able to suggest likely inter-island connections and disjunctures.

The principal advantage of such museum studies arises from the hypotheses about population structure and interaction that may be framed as a result of such work. Further testing of these hypotheses, of course, will depend ultimately on additional research at museums and on biogeographically-designed fieldwork.

Prehistoric Diversity

While a certain amount of research that might be labelled archaeological in character was carried out in the Solomons in the years prior to the Second World War, planned surveys and controlled excavations were not attempted until 1964-1966. William Davenport (1972), a social anthropologist at the University of Pennsylvania, excavated at archaeological sites on Santa Ana (Owa Raha) and Santa Catalina (Owa Riki) islands south of San Cristobal while he was in the area as an ethnologist. Also in 1964, Keio University in Japan sent an archaeological and ethnological expedition to the Solomons to survey parts of Choiseul, New Georgia, Simbo, Ganongga, Vella Lavella, and nearby islets. Masashi Chikamori conducted excavations on Vella Lavella (Chikamori, 1967).

Since these first explorations, work has been done on Buka (Specht, 1969), Bougainville (by this author), the Shortlands (Irwin, 1972, 1973), Bellona (Poulsen, 1972), Kolombangara (Kirsch, pers. comm.), Guadalcanal (Davenport, 1968), and in the area of the southeastern Solomons and Santa Cruz Islands (Green, 1973).

The increasing interest in the prehistory of the Pacific is reflected in the rapid growth in the pace of field research in the archaeology of the Solomons since 1964. There is reason to believe, nonetheless, that the aims and research designs of only some of these field projects have been such that their results may be readily and extensively utilized to explore broader questions pertinent to the biogeography of man in the archipelago. While this observation could be argued, it may be enough to claim that the surveys and excavations conducted on Bougainville and in the Shortland Islands were undertaken to explore the prehistory of those islands in ways which may now be defined succinctly as biogeographical in intent (Irwin, 1972, 1973; Terrell and Irwin, 1972; Terrell, in press). In addition, the extensive research project organized by Roger Green of Auckland University in the southeastern Solomons, while designed chiefly to pursue issues in culture history concerning the origins of the Polynesian peoples, promises to supply information bearing upon human biogeography.

There may be inevitable difficulties which will have to be faced during any attempts to interpret archaeological evidence in ways commensurate with procedures, concepts, and models used in biogeography. Such difficulties may include the fragmentary and selective nature of the archaeological record, chronological imprecision, conflicting interpretations of the same evidence, and the like. Nonetheless, efforts toward this end will be crucial in human biogeographical research in the Solomon Islands. Just as paleontological studies are fundamental to work in plant and animal biogeography, archaeology is the most reliable means by which explanatory models and hypotheses purporting to explain human diversity and human biogeographical patterns in the Solomons can be given the test of time.

ANALYSIS AND SYNTHESIS IN HUMAN BIOGEOGRAPHY

In a popular article on the Solomons, written some years ago, Ernst Mayr (1943, p. 30) asserted: "There is probably no island

group in the world that surpasses the Solomon Islands for variety. Only one general statement can be made about them and that is that one cannot generalize." Although his explicit reference is to their geologic diversity and ethnic complexity, the hyperbole in his claim should not detract from its broader relevance. The brief survey of lower animal and human diversity in the archipelago just presented suggests that these islands offer a great deal of grist for the biogeographer's mill.

The Solomon Islands research program, commenced at Field Museum in 1973, has these objectives:

1. As MacArthur (1972, p. 77) has insisted: "The concept of pattern or regularity is central to science." The first and fundamental objective of the Solomons program is to determine how successfully one can recognize patterns in human biological and cultural diversity repeated in space from one locale or area to another, and repeated, as well, in data reflecting differing aspects and characteristics of human settlement and adaptation. Prime emphasis, in short, is on phenomenology and pattern recognition.

2. Phenomenology denotes classification along with description and implies a low order of synthesis. Pattern recognition, however, signifies something more. "Pattern implies some sort of repetition," as MacArthur has also written. "The existence of the repetition means some prediction is possible" (MacArthur, 1972, p. 77). The second objective of the Solomons Program aims at a higher level of synthesis than the first: to discover how effectively simple models, either graphical or algebraic, may be developed to predict geographic pattern variation among tropical populations of subsistence horticulturalists.

3. No serious anthropologist would contend the assertion that man's capacity for culture and complex decision-making places man apart from other species populations. Yet few anthropologists would be brave enough to say where the threshold lies between man-as-biological-organism and man, the bearer of culture, man the decision-maker. For this reason, one goal of the Solomons project is to discern how legitimately models constructed solely with animal populations in mind may be applied to human populations as well. The operative questions being asked are: What factors, if any, must be introduced to model human populations that are not considered relevant to other species populations? Under what circumstances are they required? Are they universally needed whenever human

populations are being studied? Or do they apply only in certain situations?

These are the three principal aims of the comparative biogeography program. Before describing two examples of research which has been done to further these aims, however, a few additional points must be emphasized. First, a philosophical comment. For the most part, the problems being pursued during the current program are ones suggested by evidence from the Solomon Islands. Nonetheless, sound research proceeds in two complementary directions: from evidence to synthesis, and from model-building to the search for supporting and refuting data. None of the three objectives outlined here, therefore, is held to be of greater weight than the others.

Second, the relevance of models, concepts, and procedures taken from other disciplines, notably population biology, locational geography, and theoretical biogeography, is considered one of the objects of study, *not* a foregone conclusion. There is good reason for this position. As the geographers Chorley and Haggett (1969, pp. 21-26) have insisted, a model is a simplification of reality and must not be confused with reality itself. The biologist Levins (1966, p. 430) has phrased the case in unmistakable terms: "all models leave out a lot and are in that sense false, incomplete, inadequate." It would be naive to hope that a given model, concocted in one discipline, could be carried over, wholly and without modification, to serve double-duty in another, to handle problems and assumptions perhaps quite removed from those for which it was initially conceived. Indeed, Levins has argued that even a single problem within a single field of study is wisely attacked, not with one, but with several alternative models, each grounded on its own set of simplifications. "Then, if these models, despite their different assumptions, lead to similar results we have what we can call a robust theorem which is relatively free of the details of the model. Hence our truth is the intersection of independent lies" (1966, p. 423).

Levins' conclusion might be taken to infer that what goes on in one discipline could scarcely have relevance to another. So pessimistic a claim, however, need not be made, for as he himself has observed: "The validation of a model is not that it is 'true' but that it generates good testable hypotheses relevant to important problems" (1966, p. 430). In other words, relevance must not be confused with truth. In a sense, even a "false" hypothesis is better than

no hypothesis at all, because hypotheses frame and direct useful research.

Scott Boorman (1972, p. 393) in a review of MacArthur's *Geographical Ecology*, has argued the case for the relevancy of biological models to the social sciences. In his opinion, modeling efforts in contemporary mathematical social science show signs of "incipient arteriosclerosis." Social scientists would benefit from knowing more about model-building in ecology and related disciplines today because these fields, in contrast, "are showing enviable ingenuity in attacking some of the same theoretical problems that social science faces." Boorman is cautious in reaching this observation. He acknowledges that human populations are cultural and can be more intricately organized than animal populations. Moreover, decision-making may affect the behavior of human populations in unexpected ways. Thus he concludes: "Work in biological ecology and in population biology as a whole can at most stimulate human social science; it can neither subsume nor be subsumed by it."

What Boorman seems to mean, however, by "social science" is modern economics and the sociology of complex urban societies. Perhaps biological model-building can be merely provocative and stimulating in sociology and economics. Yet common sense suggests that anthropologists, archaeologists, and other social scientists working with human populations of lesser size and complexity than modern urban centers and political states might find more than enviable ingenuity in the work of theorists and phenomenologists such as MacArthur, Diamond, Wilson, and Levins. Population biologists are not unaware that this likelihood exists. Jared Diamond (1973, p. 768), for instance, has proposed that the models developed by MacArthur and Wilson might be useful in studying human evolution and could help account for striking parallels between human and bird distributions in New Guinea.

The significance of biological models for social science is not something to be assumed or rejected out of hand. Rather, their fitness in social science needs to be determined by setting data against model and observing what persists. Two research examples may serve to give substance to this abstract argument. The problem in each is different. The first explores the question of whether a fundamental kind of biogeographical patterning commonly observed for species diversity among other animals in the tropics has any parallel in human diversity in the Solomons: specifically, in

linguistic diversity. The second asks whether a few elementary measures often adopted as simplifications in biological and geographical model-building, have some predictive rigor, as well, in modeling interaction patterns among human populations living in the Solomons archipelago. While these examples are basic and relatively unsophisticated, the results obtained have proved to be intriguingly useful.

Area-Diversity Patterns:

A dictionary definition of the word *area* is "the amount of surface contained between given limits." Measuring the amount of land surface in some biotic region or sampling locality is clearly important in determining species population densities and other indices of abundance. But does the concept of area itself have much theoretical value? The answer would have to be affirmative, at least in the sense that measures of area constitute a useful simplification of complex reality.

One function of area determinations in theoretical population biology has been described succinctly by MacArthur and Wilson (1967, p. 8):

Theories, like islands are often reached by stepping stones. The "species-area" curves are such stepping stones. Our ultimate theory of species diversity may not mention area, because area seldom exerts a direct effect on a species' presence. More often area allows a large enough sample of habitats, which in turn control species occurrence. However, in the absence of good information on diversity of habitats, we first turn to island areas.

Figure 3a, from Greenslade's (1968b, fig. 2) paper on island patterns in Solomon Islands bird fauna, shows graphically how useful a measure area can be in biogeography. When the number of land and freshwater bird species encountered on each of the main islands in the archipelago is plotted against the log of the land area of each, a positive correlation between area and species diversity results. A biogeographer would not be too far off the mark if he tried to predict the number of species on a given island in the Solomons knowing only the line of regression and the island's area (Diamond and Mayr, 1976).

This kind of positive relationship between species diversity and land area is often observed in biogeography. In the words of MacArthur and Wilson (1967, p. 8): "There exists within a given region of relatively uniform climate an orderly relation between the size of a sample area and the number of species found in that area." These

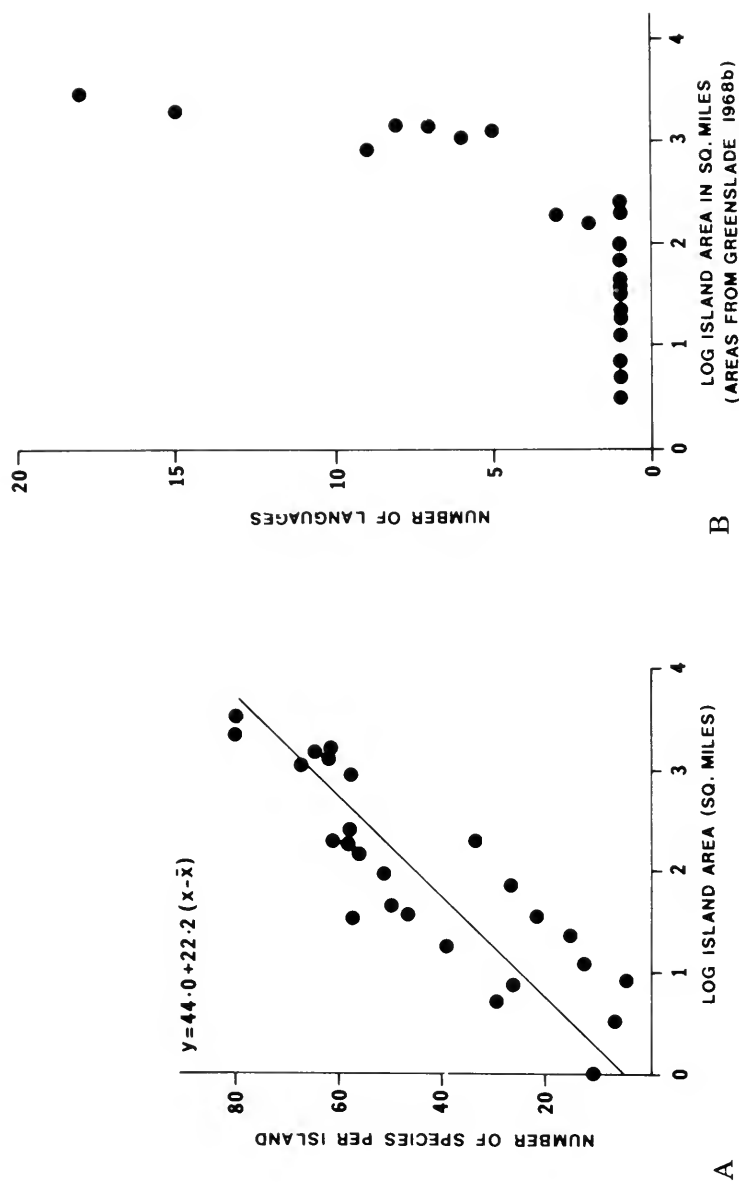


FIG. 3. a, The relation between island area and number of land and freshwater bird species (*simplified after: Greenslade, 1968b, fig. 2*). b, The relation between island area and number of languages spoken on an island in the Solomons.

authors have demonstrated that this relationship can be treated mathematically and may be used to develop a number of productive models in island biogeography referring to biotic equilibrium and the dynamics of species immigration and extinction on islands of differing size and distance from each other or from mainland areas. Moreover, Simberloff and Wilson (1969, 1970) and Diamond (1969, 1971, 1973) have reported field evidence confirming the general effectiveness of the MacArthur-Wilson models.

An obvious question, therefore, arises in human biogeography: does human diversity also correlate in a positive way with island area in the Solomons? As Figure 3b illustrates, the answer seems to be "yes." Before examining this relationship more closely, however, a few preliminary remarks must be considered.

First is the question of taxonomy. In lower animal biogeography, "number of species" refers to the total count of recognizably distinct species in a designated faunal set recorded for a given locality. In considering diversity in man, however, "number" can never refer to different species of men, but only to some taxonomic measure of observed qualitative or quantitative differences between populations *within* a single species, *Homo sapiens*. This distinction between species diversity in biogeography and population diversity in human biogeography is unquestionably important to the biologist and the evolutionist. Yet the distinction is, in a real sense, only one of degree. Raising it here merely helps underscore the fundamental role played by taxonomic classifications in composing area-diversity curves in either case.

Second, common sense dictates that the degree of human diversity observed on a given island in the Solomons should vary according to the kind of biological or cultural trait examined. This observation is less important than it might seem to be. Similar variation also appears in lower animal biogeography, depending on the kinds of species enumerated. In both human and animal biogeography, therefore, it will not do to count apples in one area and oranges in another and then expect an orderly relation to appear. Similarly, the unit of measure used to determine area cannot be changed at will without disrupting the comparative results.

Returning to Figure 3b, note that the number of reported languages spoken on 24 islands in the Solomons have been plotted against log-island area. The language counts are taken chiefly from the lists provided by Capell (1962) and Allen and Hurd (n.d.). In

view of earlier comments regarding the limitations of current linguistic evidence, these figures undoubtedly vary greatly in their accuracy. The island areas are those given by Greenslade.

If these likely sources of error are ignored, what observations can be made about the area-diversity curve for Solomon Island languages? Unlike the case in bird faunas, the relation between island area and the number of languages is not clearly linear. There is a break in the curve roughly after the log for an area of 100 sq. miles. Only single languages are spoken on islands below that value. Thereafter, however, the number of languages seems to increase rather orderly: one for about every 190 sq. mile increment in island area.

Forty years ago Ludwik Krzywicki (1934, pp. 20-21) suggested that primitive man, when he left behind him the stage of nomadic hunting and gathering and settled down to cultivate the ground, not only increased in numbers, but also experienced a profound change in the fabric of his social life: "we should call attention to the fact that settled life in general at first weakens the intensity of social cohesion. The ethnic unit is larger: a greater number of persons speak the same language, which is divided only into dialects differing but little from each other. But in the very nature of primitive settling there are inherent factors which counteract the growth of mutual cohesion."

According to Krzywicki's (1934, pp. 50-51) view of man's economic and social evolution, primitive agriculturalists, because they are bound to the soil they cultivate, find themselves living apart in "very small groups (or communities) — parochial groups, to borrow a term from mediaeval examples — with similarly parochial views." While they may have a sense of broad ethnic identity, each settlement leads its own life as an autonomous village community: a separate, independent social entity, often indifferent to the fate of its nearest neighbors and sometimes even hostile to them.

Recently and independently, Jon Friedlaender (1971) and I arrived at conclusions with regard to the village subsistence cultivators of Bougainville Island which are in essence those proposed earlier by Krzywicki. Our field data, in conjunction with previous ethnographic testimony, indicate in particular that these Solomon islanders are remarkably sedentary. For example, Friedlaender's information on current marriage migration patterns for 18 villages in central and southern Bougainville reveals that the great majority

of married adults (86 per cent) live within only a kilometer or two of their birthplaces, and very few (5 per cent) live more than 10 km. distant (Friedlaender, 1975). Both Friedlaender and I have noted that a distance on this last order of magnitude well approximates the average geographical radius of the numerous languages spoken on the island. Both have inferred, not unexpectedly, that this linguistic pattern reflects the highly sedentary life of the islanders and, more fundamentally, their extremely localized ecological dynamics (Friedlaender, 1975; Terrell, 1976, in press).

This line of reasoning may be taken to suggest the factors responsible for the language area-diversity curve depicted in Figure 3b for the Solomons in general. They are: (1) distance and (2) population size and settlement density. Under traditional socio-economic conditions in the Solomon Islands, it seems that a language population may attain only a certain maximum spatial dispersion without differentiating into mutually unintelligible daughter languages. Judging from the curve in Figure 3b, it may be inferred that distance begins to affect intelligibility somewhere in the areal range between 100-200 sq. miles. Once this distance limit is exceeded, the frequency of interaction between settlements, or to use Krzywicki's terms the "intensity of social cohesion," reaches the point where a more or less homogeneous language, or set of mutually intelligible dialects, can no longer be maintained and language divergence begins to set in.

A transcription into graphical form of these likely factors contributing to linguistic divergence between speech communities is shown in Figure 4a. The graph is MacArthur's and Wilson's familiar equilibrium model predicting the number of species in the biota on a given island as a function of species immigration from a source region and local species extinction. In the present instance, however, the rate function originally called "immigration of new species" has been interpreted as "borrowing of new words" from some other speech community. Similarly, the increasing function originally termed "species extinction" is here labelled "loss of shared words." The intelligibility between two communities in speech behavior, expressed as the number of shared or "cognate" words used in common, is illustrated as the equilibrium value (\hat{c}) at the intersection of these two functions.

This simple representation takes into account neither variation in the effect of distance on social interaction among communities, nor variation in the modes of interaction employed. Moreover, this

figure does not reflect the likelihood that population size, particularly in terms of the number of settlements for a given land area, may affect the cohesiveness of a language population. A more realistic model, therefore, would be one offering a range of intelligibilities or cognate percentages, depending on varying kinds of interactive mobility and alternative settlement densities. Figure 4b presents such a model, one which is also a direct borrowing from MacArthur and Wilson (1963).

The example of one Solomon Islands language which has an uncommonly wide area of occurrence will illustrate how distance and settlement density influence the territorial dimensions of a language population. The largest single language group on Buka Island and the northern end of Bougainville is the *Halia* language (some 10,000 speakers). Unlike the restricted spatial pattern observed for the other languages spoken on Buka and Bougainville, *Halia* is spoken along a narrow strip of coast on both islands, for a distance of some 45 miles. Yet, in spite of the fact that *Halia* has apparently been in use for several thousands of years in its present location, it has only differentiated into a chain of four dialects which are less like each other the farther apart they are along the coast:

<i>Haku</i> Dialect (N.W. Buka)			
78%	<i>Halia</i> Dialect (N.E. Buka)		
73%	84%	<i>Hangan</i> Dialect (S.E. Buka)	
57%	75%	79%	<i>Silao</i> "Sub-language" Dialect (N.E. Bougainville Island)

[data: similarity figures from Allen and Hurd, *n.d.*]

Comparative study of the geography of all the languages of Bougainville and Buka (Terrell, 1976, chap. 2, appendix II) suggests that several specific circumstances have maintained *Halia* as a chain of mutually-intelligible dialects, rather than as a set of historically-related languages. These local conditions are: (1) the coastal location of the language communities and the reported ease of travel by sea and over the level coastal terrain; (2) the high density of population (the highest on these islands: ca. 160 people per square mile); and (3) the corresponding high number of village settlements (over 30 at the present time) situated in close proximity to each other along the coast. Elsewhere on Buka and Bougainville such a combination of circumstances does not pertain. In spite of sizable populations in some instances, the maximum distance between the

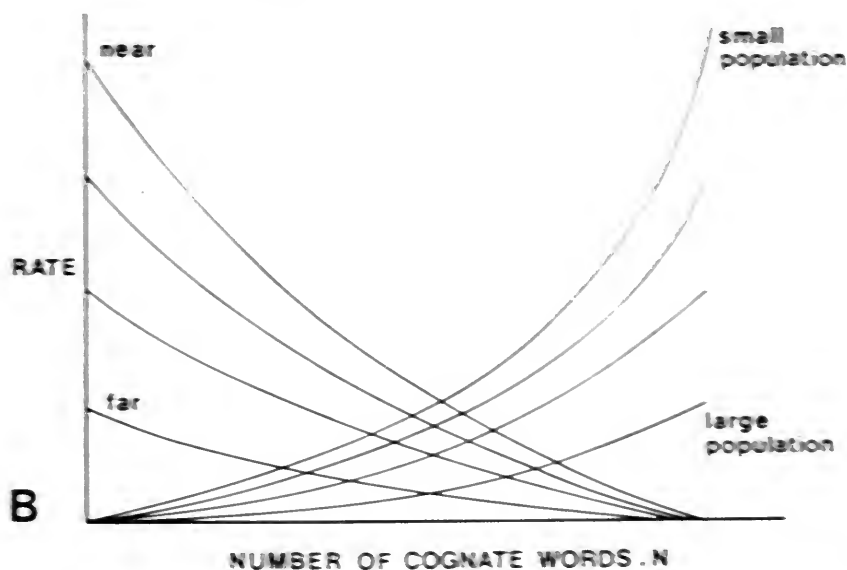
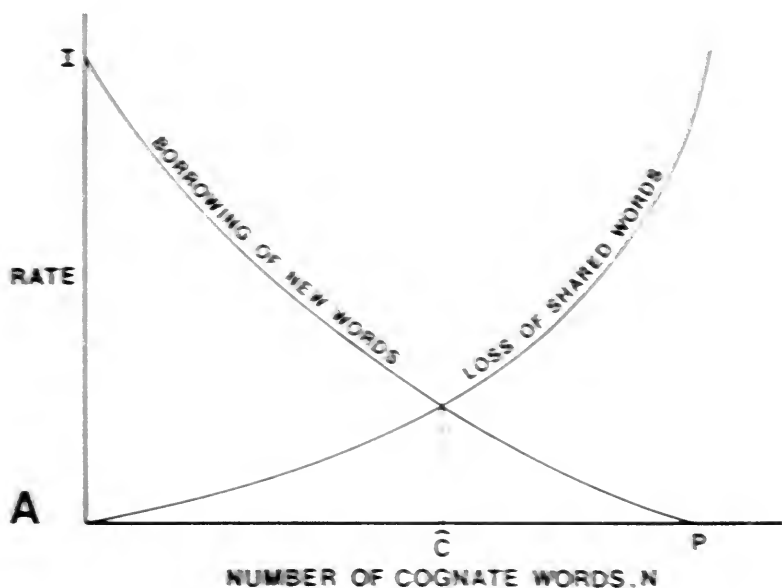


FIG. 4 a. An equilibrium model of linguistic intelligibility (cf. MacArthur and Wilson, 1968, fig. 4) b. Equilibrium models of linguistic intelligibility between populations of differing size and at varying distance from each other (cf. MacArthur and Wilson, 1968, fig. 5)

TABLE 1

Island	Area ⁴ (sq. miles)	Expected Languages	Estimated Languages	Deviation
Rendova	147	1.55	2	0.45
Vanugu	210	1.88	3	1.12
San Cristobal	1193	7.00	6	1.00
Choiseul ¹	1145	6.75	6	0.75
Isabel	1581	9.02	8	1.02
Malaita ²	1663	9.45	8	1.45
New Georgia	789	4.89	7	2.11
Guadalcanal	2039	11.40	14	2.60
Bougainville ³	3317	18.06	18	0.06

¹Scheffler, 1965²Ross, 1973³Allen and Hurd, n.d.⁴Diamond and Mayr, 1976

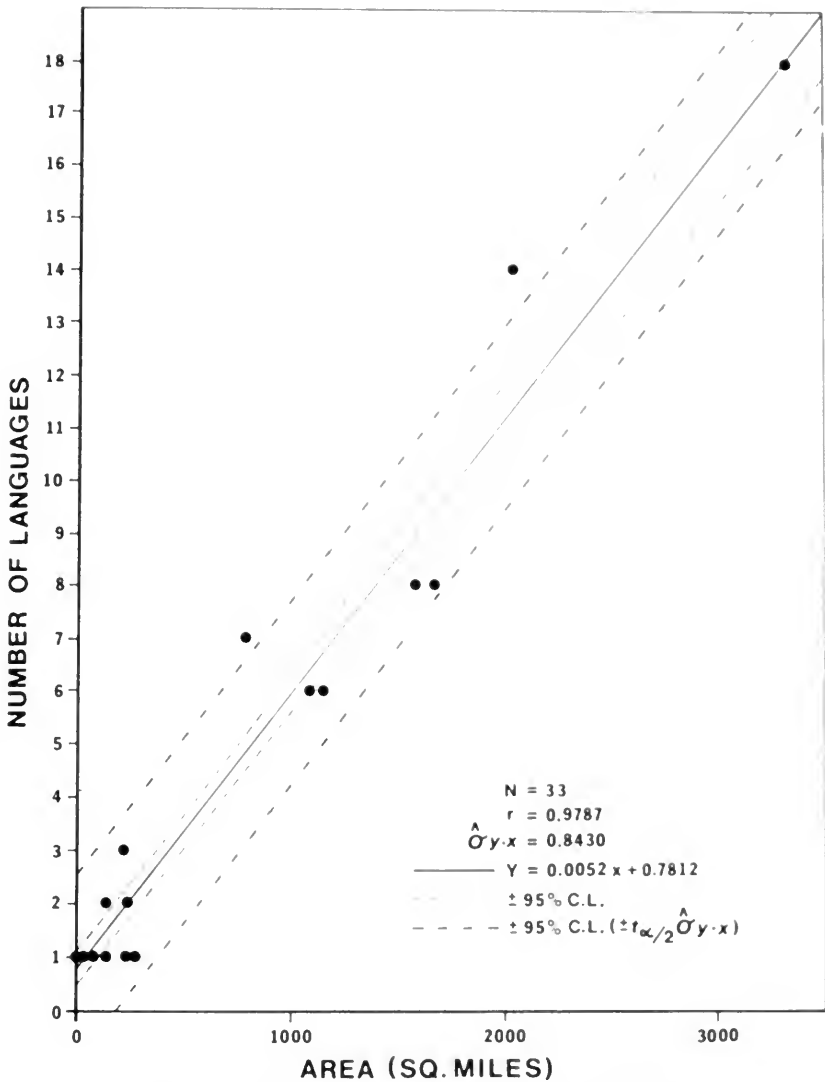
two most separated villages in each of the remaining languages averages only 20 miles.

The exceptional status of *Halua*, therefore, may be cited not only to define the likely manner in which particular local circumstances affect the geographic range of a language in the Solomons, but also to propose why it should still be possible to predict rather closely (table 1) the number of languages spoken on a given island from knowledge only of the area of the island in question and the calculated line of regression for the archipelago as a whole (fig. 5). Apparently the ecology of human settlement in the Solomons is sufficiently commensurate from island to island, and geographic variations are sufficiently comparable, regardless of the island, that an orderly relation between language diversity and island area has, nonetheless, been achieved.

While the area-diversity curve recognized for the Solomon Islands may be altered with the acquisition of more reliable data on the languages of the region and island areas, it would be surprising if the broad pattern discerned were wholly discredited, in view of the size of the island sample and the high correlation value obtained ($r = 0.9787$).¹

The area-diversity pattern is not trivial. It affirms that human biogeographical research in the Solomons will not be fruitless. It

¹Accepting the data given by Hackman (1968), a similar correlation is obtained ($N = 32$, $r = 0.9661$, $m = 0.0059$, $b = 0.8540$).



historical linguistics. Even granting probable differences in the time-depth of first human settlement in Melanesia and Polynesia, for example, it may not be as remarkable as often thought that the large islands of Melanesia are more linguistically diverse than the small island groups in Polynesia.

Proximal-Point Analysis:

The second example of current efforts to develop predictive models defining the probable behavior of human populations in the Solomon Islands, utilizing principles already explored in biogeography and here also modern locational geography, is illustrated in Figure 6. The network graph shown superimposed over a conventional map of the Solomons depicts the most likely directions of inter-island movement if only two variables, distance and area, are assumed to govern frequency of interaction. The procedures followed to construct this network model can be simply described.

Perhaps the best known mathematical model in geography is the "energy of interchange" or "gravity" model, associated closely with the work of John Stewart, an astronomer, and G. K. Zipf, pioneers of contemporary quantitative geography (Stewart, 1947; Stewart and Warntz, 1968). As Gerald Carrothers (1969, p. 226) has described this model:

In general terms, the gravity concept of human interaction postulates that an attracting force of interaction between two areas of human activity is created by the population masses of the two areas, and a friction against interaction is caused by the intervening space over which the interaction must take place. That is, interaction between two centres of population concentration varies directly with some function of the population size of the two centres and inversely with some function of the distance between them.

Phrased in the most elementary mathematical fashion the frequency of interchange or interaction (I_{ij}) between two populations located at points (i) and (j) may be predicted from the size of each population (P_i , P_j) and the distance separating them (d_{ij}), raised to an exponent (b) to allow for the likelihood that the effects of distance will vary from one kind of situation to another and with the methods of interaction and movement employed (Harvey, 1969, pp. 559-560):

$$I_{ij} = \frac{P_i \cdot P_j}{d_{ij}^b}$$

Carrothers (1969, pp. 236-237) has remarked upon the major difference between this model and that expounded in Newtonian phys-

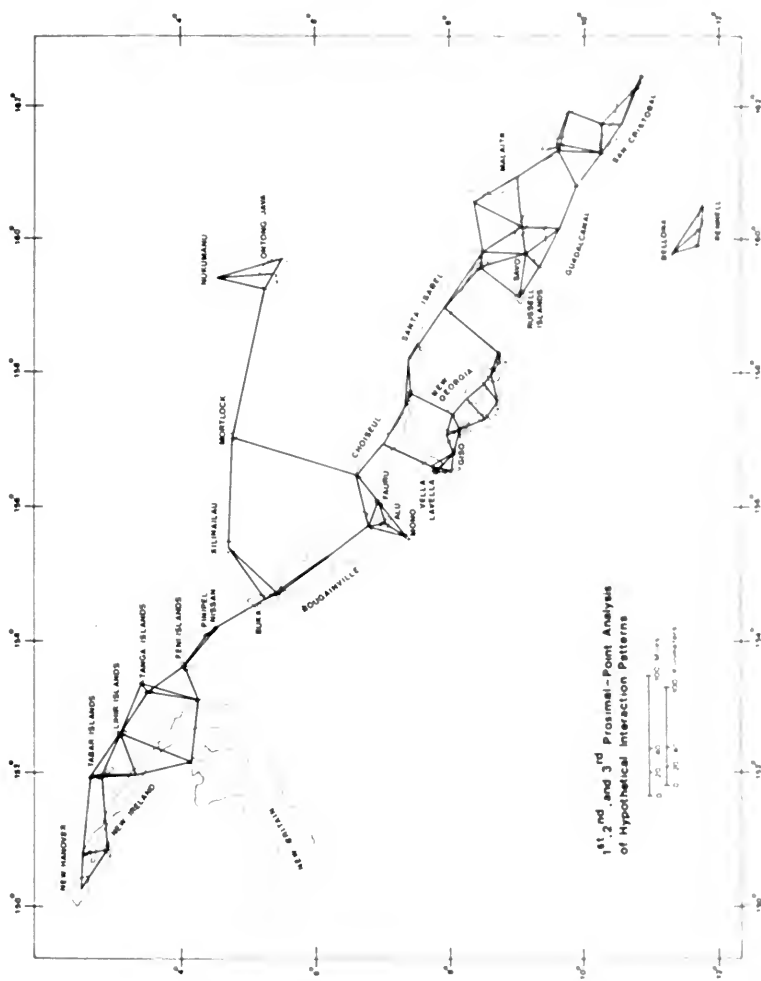


FIG. 6. 1st, 2nd, 3rd proximal-point analysis of hypothetical interaction patterns among the Solomon Islands. See pp. 36-37 for explanation.

ics. Neither formulation purports to forecast the behavior of individuals, be they molecules or persons. Both only attempt predictions about large, aggregate numbers of individuals. However, people make decisions regarding their behavior; molecules do not. There must be, therefore, a threshold "where the power of individual decision-making critically affects the results" obtained by the geographic analogue. While this limitation may be significant (Sack, 1971), one way around it is to use the model and then judge the effectiveness of the results. This pragmatic approach is taken here.

MacArthur and Wilson (1967, pp. 19-41), in their theoretical investigations on island species diversity, make use of variables akin to those contained in the gravity model. In their usage, however, island area assumes the kind of role played by population size in the latter. Their aim is to develop an equilibrium model predicting, not population interaction, but rather the dynamics of species immigration and extinction. In spite of these differences, the parallels between their approach and interaction models are brought out, for example, when they comment that their model "leads to the prediction that the logarithm of the number of species should increase with area more rapidly on distant islands than on near islands, and should decrease more rapidly with distance on small islands than on large islands" (MacArthur and Wilson, 1967, p. 66).

Possibly the main difference between the basic equilibrium model created by MacArthur and Wilson (which, as noted earlier, defines the number of species on an island as a balance between the rate of immigration of new species to the island against the rate of extinction of species from the island) and the gravity model used in geography lies in the fact that the equilibrium model is less concerned with actual frequencies or rates of extinction and immigration than with the relation or ratio between these two processes. As it will soon become apparent, the island model described here for the Solomons is also one dealing more with ratios than with calculated interaction frequencies, although the assumptions on which it is grounded are those common to both the MacArthur-Wilson and gravity models.

The elementary network graph appearing in Figure 6 represents one attempt to see what kinds of interaction patterns should be expected among the Solomon Islands if measures as fundamental as distance and area strongly predict the spatial movements of the islanders. The procedures followed to sketch the network shown

require nothing more elaborate than a pair-of-compasses, a ruler, and a pencil.

In constructing the model it was necessary, first of all, to simplify the complexities recorded on geographic maps of the archipelago. Intuitively, the decision was made to let dots, or single points, represent small islands. Such a reduction will hardly do in the case of large islands, however, where it would lead to the loss of all dimensional information. Because the main islands in the Solomons are remarkably elongate, due to their underlying physical geology, large islands were reduced in the figure to more or less straight lines, defined by three points: a mid-point and two end-points at the farthest extremes roughly located on a line through the mid-point.

After these points had been determined for all islands, three lines were drawn out from each to the three other points found to be closest or most "proximal" to each point. This geometric procedure graphically expresses the assumption that, since these points are closest, they are also the ones most likely to be contacted from each point of origin, if all of them were in truth human settlements. The final network of points and lines depicted in Figure 6 portrays schematically the most probable directions of inter-island trade, travel, inter-marriage, migration, and the like, provided that measures of area and distance accurately predict the most probable paths of interaction, and also that the simplifications introduced have not critically distorted either geographic reality or those measures. One further assumption is hidden in the network which must be specified if the diagram is to be interpreted correctly.

The procedure of drawing three lines out from every single point reflects the assumption that village settlements in the Solomons all enjoy an equal status and that none performs centralized, specialized functions for its surrounding neighbors. For the most part, this assumption seems reasonable as a characterization of the egalitarian societies found in Melanesia at the time of first European contact. In most areas of the world today, even in Melanesia, it would be necessary to weight the points in Figure 6 according to some formula predicting the position that a given hypothetical settlement is likely to hold in a non-equivalent, hierarchically ordered network system of social, religious, political, and economic interactions: predictions of the sort attempted in modern locational geography by Central Place theory and the like (Haggett, 1966, pp. 114-152).

If, nonetheless, the assumption is accepted for the Solomons that all points in the network are equivalent, then the model may be read directly to reach predictions concerning: (1) the *relative frequency* or *ratio* of interaction among selected points in the hypothetical system (by comparing the lengths of the lines drawn and considering the distance exponent to be invariant), (2) the *efficiency* of interaction among any set of points in the system (by constructing distance matrices, see: Harary et al., 1965), (3) the degree of connectivity in the system taken in whole or in part (Haggett, 1966, pp. 70-72, 238-239), and so on.

In short, the network model leads to hypotheses about, first, how island interaction is patterned in the archipelago, and second, the kinds of pattern variation to be expected in any cultural or biological trait of the islanders believed sensitive to change in interaction frequencies. For example, since languages are usually thought to diverge under conditions of isolation, the model may be interpreted to suggest that the northern Solomons (Buka and Bougainville) and the western Solomons (Vella Lavella-New Georgia) are probably dissimilar, linguistically, from the highly interconnected southeastern Solomons: a prediction in apparent agreement with existing language evidence noted earlier.

As this one example illustrates, hypotheses from the model can be tested. Predictions about island interaction patterns may be assessed by determining what actually happens during trade and travel in the Solomons through field observation and study of the ethnohistorical literature. Predictions about pattern variation can be tested by phenomenological study of trait diversity.

Tests of both sorts are in progress at Field Museum. For instance, detailed ethnohistorical and archaeological information has been gathered on trading systems and interaction spheres in the northern Solomons: on the one hand between Buka, Nissan, and New Ireland (Kaplan, 1976) and on the other, between southern Bougainville, the Mono-Shortland Islands, and Choiseul (Terrell and Irwin, 1972). In both areas, the correspondence between the network model and attested reality is, as Kaplan has previously remarked, strikingly close. Similarly, what Cummings (1973) has written about geographic variation in compound fish-hook types throughout the Solomons matches well with what one would predict from the model. Further, considering what Roger Green (1973) has written about trade and cultural affinities in the southeastern Solomons, it is likely that the model may hold for that region as well.

If proximal-point analysis proves to be as predictive as available evidence suggests, there is good reason to suspect that much of the bewildering array of diversity in the Solomon Islands may be explicable with the aid of a very few basic propositions about the spatial organization of interactions among the island populations. The generation of diversity through environmental adaptation may be of limited importance: a conclusion which might be expected considering how little the environment seems to vary from one part of the island chain to the other.

However accurate the network model may ultimately appear to be, it has one unquestionable virtue: the hypotheses it generates orient research in explicit directions. In fact, it will be the exceptions to the model that will stand out with great clarity as prime areas for study.

In summary, modeling procedures, such as elementary proximal-point analysis, hold out promise of being able to resolve problems of long-standing interest referring to the probable causes of the uncommon degree of biological and cultural diversity found among the Solomon Islanders. In the future it would be possible, of course, to generate with the aid of computer techniques more complex models than that presented in Figure 6. Thus far, no occasion has arisen when it seemed necessary to abandon pencil and paper and do away with the simplifying steps required by the manual technique outlined above. It is rare, however, that old puzzles are solved without revealing new problems previously obscured by the old ones. Needless to say, new problems usually demand new techniques for their solution.

RETROSPECT AND PROSPECTS

Human biogeography has been defined as the study of human populations, their characteristics, organization, and behavior, and of the conditions and kinds of events that lead to the growth and maintenance of similarities and differences among human populations at various points on the earth's surface and at various times in man's history. What distinguishes human biogeography from other related, older disciplines, such as social anthropology and cultural geography, is at least twofold. Biological populations, rather than geographical regions or the cultures and societies of the anthropologist, are considered the fundamental unit of interpretation. Research is focused on discovering how human populations are distrib-

uted over the face of the earth, how they are affected by their size, growth, geographic location, and habitat, and how their relations, or interactions, with the natural world and with other human populations are influenced and structured by the conditions under which they live.

The argument has been made that evidence suitable for the study of the biogeography of man may be found not only by analyzing the distributions of human similarities and differences, but also through comparative research on other animal species. Indeed, it has been suggested that contributions by ecologists, theoretical biologists, and biogeographers should prove extremely helpful in developing suitable procedures, concepts, and models to describe and explain the characteristics and behavior of human groups.

In support of these propositions, two examples of research on the human biogeography of the Solomon Islands in the southwest Pacific were described. In the first, it was observed that there appears to be a positive correlation between island area and the number of languages spoken on an island, a relation so direct, in fact, that it is possible to predict the number of languages on any given island in the Solomons knowing only its land area and the calculated regression for the archipelago as a whole. This relation closely parallels similar ones reported for other animal species in the Solomons, and reveals a correspondence between human and animal populations few anthropologists might have anticipated.

In the second example, two fundamental variables, area and distance, often used to develop spatial models in economic geography and theoretical island biogeography, were adopted to construct a simple network model predicting patterns of interaction among the islands in the Solomons chain. Following a procedure developed here called "proximal-point analysis," it was shown that the resulting model successfully anticipated patterns of trade, inter-island voyaging and cultural diversity.

Although much information on human diversity in the Solomons is needed before great advances can be made in the biogeography of the islanders, results obtained thus far hold out promise that work along the lines sketched in this survey will be practical and illuminating. It is likely that comparative research on the ecology and biogeography of both human and other animal populations will resolve one of the great riddles of the Pacific: the extraordinary biological and cultural diversity of the island world of Melanesia.

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